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Interim Report on Grant 75-2812
"Numerical Studies in Computer-Aided Design"
D. A. Calahan, Principal Investigator
University of Michigan
Grant Period: 4/1/78-3/31/79

I. Research Objectives in Progress

Two study objectives were supported by this grant.

A. Study of vectorizability of aerodynamic fluid flow codes (AFFDL). An explicit 3-D aerodynamic simulation code (exercised in 2-D) was vectorized in Fortran and coded in CRAY-1 assembly language. The latter was greatly assisted by use of a CRAY-1 simulator and a cross-assembler developed under grant sponsorship [4][5]. Major subalgorithms from these codes were benchmarked and reported in [3]. The complete code has also been vectorized in Fortran and assembly coded and is planned for final benchmarking this spring. Speedups on the order of 100 are indicated viz-a-viz the CDC 6600.

B. Study of the development of linear algebra codes and sparse matrix algorithms for the CRAY-1 (AFOSR/AFFDL): A study of the relatively poor performance of a sparse matrix code developed without the aid of simulation [8] indicated the importance of data flow considerations in addition to vectorization in the development of linear algebra algorithms for a memory-hierarchial, functionally-concurrent processer of the CRAY-1 class. Equation-solving kernels (full solvers, band solvers, tridiagonal solvers) were developed and timing models produced using simulation [2][6]. Speedups of 1.5:1 to 2:1 viz-a-viz LASL-prepared assembly language codes were obtained. These kernels will be made into an equation-solving library for the CRAY-1 for use in the public domain. They will also be incorporated in an improved sparse matrix algorithm which has asymptotic speeds approximately four times that of the previously developed code.

II. Coupling Activities

A. Air Force/Government. Besides three visits to AFFDL to coordinate the aerodynamic code development, seminars were

presented to Argonne National Laboratory (June, 1978) and to Los Alamos Scientific Laboratory (May, 1973) on the topics of the modeling and use of vector processors.

B. Industrial. Consultive studies with Electric Power Research Institute through a contract with General Electric Company were completed. These involved study of the application of vectorized sparse matrix codes to electric power system analysis and produced a report [7]. A study was completed with Mobil Oil Corporation to vectorize computation kernels used to solve 3-D diffusion equations associated with oil reservoir drilling and management.

C. Short Course. An annual one-week short course entitled High Speed Computation: Vector Processing was continued in 1978 to survey the state-of-the-art in vector architectures and related problem-solving methods. Among the attendees were representatives from Rome Air Development Center, Air Force Flight Dynamics Laboratory, Air Force Weapons Laboratory, and Air Force Headquarters, Pentagon.

III. Personnel

Professor D. A. Calahan, Principal Investigator

5 students

William Ames

Pieter Buning

Peter Goshgarian

David Orbits

Edward Sesek

Grant-support Publications

A. Conference Proceedings

[1] Orbits, D. A., and D. A. Calahan, "A CRAY-1 Simulator and its Use in Development of High Perrormance Algorithms," Proc. 1978 LASL Workshop on Vector and Parallel Processors, Los Alamos, September, 1978.

[2] Calahan, D. A., "Performance of Linear Algebra Codes on the CRAY-1," Proc. 5th SPE Conf. on Reservoir Simulation, Denver, January, 1979, pp. 120-127.

B. Conference Presentations

[3] Buning, Pieter, "Preliminary Report on the Evaluation of the CRAY-1 as a Numerical Simulation Processor," 11th AIAA Conf. on Plasma and Fluid Dynamics, Seattle, Washington, July, 1978.

C. Reports

[4] Orbits, D. A., "A CRAY-1 Simulator," Report #118, Systems Engineering Laboratory, University of Michigan, Ann Arbor, September, 1978.

[5] Ames, W. G., "A CRAY-1 Cross Assembler," Report #120, Systems Engineering Laboratory, University of Michigan, Ann Arbor, September, 1978.

[6] Ames, W. G., et al, "Sparse Matrix and Other High Performance Algorithms for the CRAY-1," Report #124, Systems Engineering Laboratory, University of Michigan, Ann Arbor, January, 1979.

Other Report References

[7] Barry, D. E., C. Pottle, and K. Wirgan, "Technology Assessment Study of Near Terms Computer Capabilities and Their Impact on Power Flow and Stability Simulation Programs," Report EL-946, EPRI, Palo Alto, December, 1978.

[8] Calahan, D. A., "Vectorized Solution of Load Flow Problems," Proc. Workshop on Exploring Applications of Parallel Processing to Power System Analysis Problems," EPRI, Palo Alto, October, 1977.